Cognition Beyond the Flesh
(Singing Burrows and Surrogate Situations)*

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1. From Finger-Wiggling to Foreign Policy

2. Singing Burrows

3. Surrogate Situatedness

4. Cognition beyond the Flesh

1. From Finger-Wiggling to Foreign Policy

- A standard worry/

The most compelling models, accounts and explanations to emerge from the new paradigms (dynamical, situated, evolutionary and embodied approaches to cognition) apply only to cases of *highly coupled unfolding*.

But these cases have special features.

- They are cases where some kind of perceptual (usually perceptual-motor) routine is attempting to solve a problem in the presence of some tangible target

Simplest example: a phototropic robot that works while the light is present.

- Or the robot cricket that must follow the call of its mates (Webb)
- Or returning a tennis serve (Port and Van Gelder)
- Or co-ordinating the wiggling of the left and right index fingers (Kelso)
- Or running to catch a ‘fly ball’ in baseball
- Or diving to catch a fish, and all the time-to-contact examples
- Or loads of work on real-world robots using just-in-time sensing routines (see
- reviews in Pfeifer and Schier (2001)
- Or (trivially) *any cases where we can indeed ‘use the world as it’s own best model’.*

Constraints:

Need to keep track of a real-world situation that is unfolding in a constraining time-frame, so real timing (absolute timing) matters, not just sequence.

Need to merge real-time action and planning and reasoning, so (??) pressure for a common code (or processing format) for perception, reason and action.

Opportunities:

Can use body, motion and world as integral aspects of the problem-solution

(eg just-in-time sensing, deictic pointers, world as own best model, action-oriented representations, etc)

Upshot: a plethora of cool and exciting treatments that 'put brain, body and world together again'..

Assessing a nation's foreign policy

Planning next year's family vacation

Designing a new 100 storey building

Doing advanced mathematics

Thinking about equality, opportunity, freedom and the negative impact of the 'war on terrorism'

Generally/

- Reasoning about the absent, the abstract, the impossible, the counterfactual.

- Reasoning in the absence of the scaffolding provided by the problem-situation itself

- Or, as many of us have glossed it, the ability to engage in 'off-line reasoning'

TMTMFW

There’s More to Mind Than Finger-Wiggling

- First, to argue that the hard-and-fast on-line/off-line distinction is itself unclear and potentially misleading. Rather, in just about all cases, we find elements of each and a constant seamless integration of the two.

See eg catching the falling shapes (Beer), reaching for a recently hidden object (Thelen et al),

- Second, to argue that even fully imagination-based, problem-situation decoupled reason is fully continuous with the other cases, because our imaginative routines are themselves *body-based, exploit egocentric co-ordinate spaces, deploy the same old action-oriented representations*, etc

See Thelen et al, Mataric , Barsalou (on perceptual symbol systems), Lakoff and Johnson on embodied metaphors etc.

The systematic use of non-biological structures to build brand new kinds of (extended) cognitive machinery.

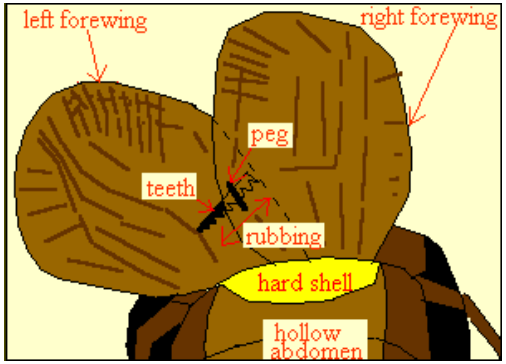
A kind of evolutionary fast-track to the production of new cognitive ‘organs of extreme perfection’.

Upshot/ The cognitive strategies that make human thought what it is are not the same ‘all the way up’ (though it can seem that way if we insist on looking for all the cognitive apparatus ‘in the head’).

2. Singing Burrows

(For the whole story, and lots of others, see J Scott Turner, ***THE EXTENDED ORGANISM*** (Harvard University Press 2002)).

Basics:



Its about crickets again.

Crickets sing to attract mates (of their species)

Louder is generally better (reaches more potential mates and impresses them more)

The onboard mechanism is stridulation= the pinging (via a tooth and peg set-up) of a flexible patch of wing membrane (the harp) held taut like a kettle drum.

Crickets are little. Their harps are small relative to the wavelength of their carrier tones.

This is very inefficient in a free (unobstructed) sound field, and much of their muscle energy is wasted, turned not into sound but lost doing capacitive and inertial work.

Typical efficiency is a paltry 1.5 to 2% (of expended pinging energy turned into sound)

A Klipsch Horn

This is a great set-up. It involves:

A horn that flares like a trumpet (aka an exponential horn), and

A capacious end bulb (eg the musician's mouth cavity) connected
by a restricted opening (eg lips, reed) to the horn.

This set-up allows the air inside the horn to be turned back to help drive the emitter (a kind of turbo-charging called 'loading the horn')

It allows the trapped air to resonate at a frequency related to the length of the horn

All this vastly reduces the amount of energy lost to capacitive and inertial work

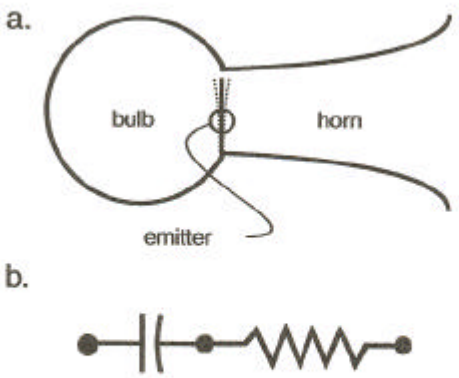


Figure 10.6 The Klipsch horn. *a:* Relative placement of the sound emitter, the horn, and the bulb. *b:* Equivalent circuit for sound energy in a Klipsch horn. The bulb acts as a capacitor in series with the emitter and the horn, which acts as a resistor.

From J Scott Turner, THE EXTENDED ORGANISM: THE PHYSIOLOGY OF ANIMAL-BUILT STRUCTURES

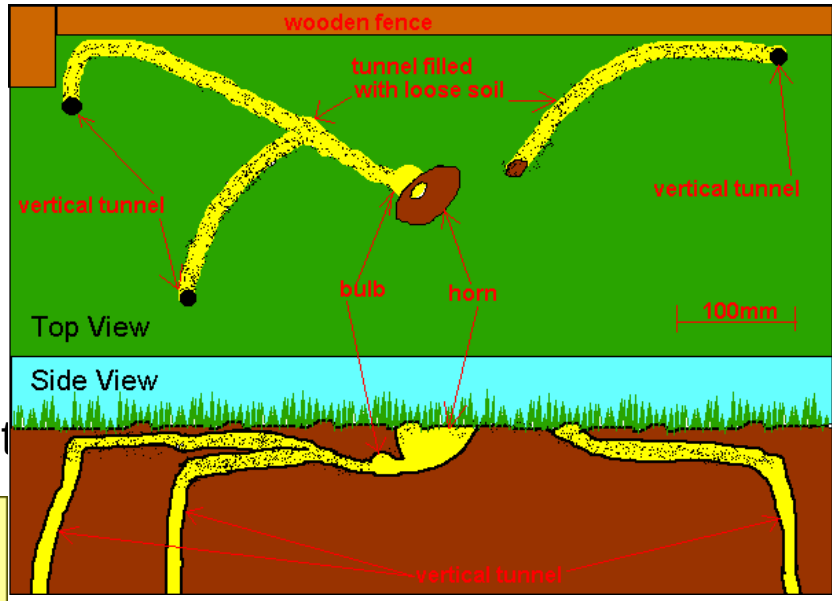
The Singing Burrow

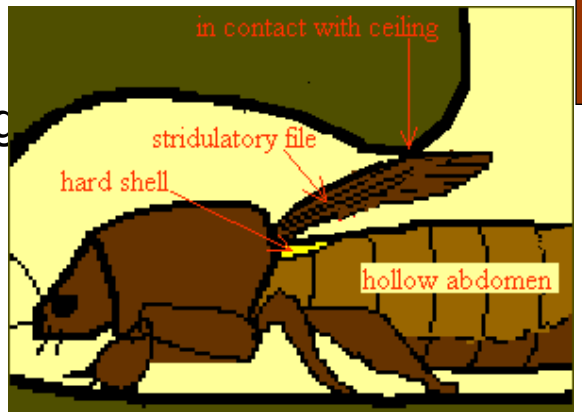
One tunnel is expanded into a large bulb

Another tunnel flares in cross-section like an exponential horn
(there can be two of these tunnels)

There is a narrow constriction between the t

Here, the tiny mole cricket sits and sing





Acoustically, this is ‘ a double exponential horn set in a flat infinite baffle (the ground)’

The burrow acts as a ‘’tuned impedance transformer’ that is fitted to the specific carrier wave frequency of the species

34% of muscle power is turned into sound (vs 2% without)

The tiny male cricket produces one of the loudest sounds made by ANY animal

It can be heard at 600 m distance and sets the ground vibrating for a 20 cm radius

Functionally equivalent to a giant cricket whose on-board physiology includes a near-perfect sound-emitting organ.

Turner's goal, in fact, is to argue that the extended system is best seen as a part of the cricket's physiology and to breach ' the essentially arbitrary boundary between organisms and the environment' p.214)

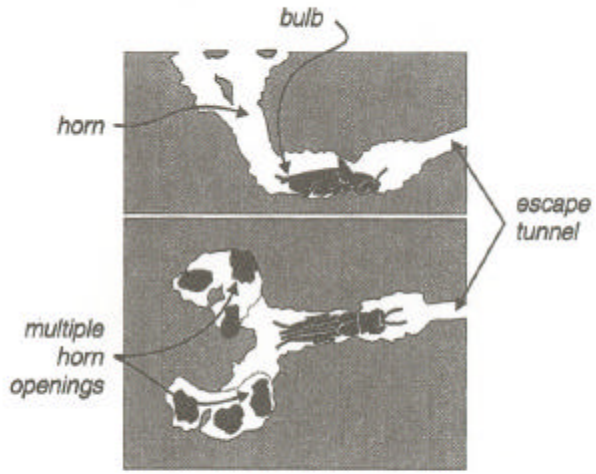


Figure 10.8 Cross-section *(above)* and top view *(below)* of the singing burrow of *Gryllotalpa gryllotalpa*. Doublet horns lead to several small openings at the surface. [*After Bennet-Clark (1970)*]

Not much.

All the genes needed to encode is a strategy for feedback-driven burrow-excavation and tuning.

On wet nights, the male digs, settles into the constriction, emits a single chirp (a test chirp) and then alters the size and shape of the horn and bulb, repeating until he hears the right resonant frequency.

Finding this strategy and loading it into the genome must be (?) infinitely faster and cheaper than making the long sequence of small changes needed to install an on-board Klipsch horn set-up.

Supposing (as I'll now argue) advanced human cognition depends on a snowball of 'cognitive singing burrows'?

What would that mean for the question of whether cognition is embodied 'all the way up'?

Suggestion:

It will mean that we need to be very careful about any claim of 'seamless continuity',

An embodied cognitive science needs to be developed in deep and delicate harmony with a better understanding of the cognitive role of external structures and scaffoldings.

These transform the extended functional architecture, and- crucially- do so in ways that relax some of the fundamental constraints on basic forms of embodied response.

3. Surrogate Situations: The Singing Burrows of the Mind

Recall the standard worry : **TMTMTFW**
Now let's pursue a different line of response:

The worry (TMTMTFW) deploys a notion of off-line reasoning that conflates:

Disengagement -reason operating in the absence of the target situation, as when we plan next week's party or design a new building

Disembodiment -reason operating without the kinds of dense, perceptually- saturated action-involving couplings that most obviously reward treatment in dynamical and situated terms.

Henrik Gedenryd

How Designers Work (Making Sense of Authentic Cognitive Activities)
(PhD Thesis, Lund University, Cognitive Studies 1998)

= a highly detailed treatment of the roles of sketching, prototyping, mock-ups, scenarios, storyboards, simulations, thumbnails etc as used in the process of designing a building, or laying out a magazine cover, or designing a new power tool...etc etc...

Notice that:

- The product **does not yet exist**. So the design problem looks truly ‘representation-hungry’ in my sense. For example, the building-to-be is spatially absent, temporally-remote, and may even turn out to be impossible to actually build.

- In addition, many of the target features will be **relatively abstract** (eg ‘a safe and inspiring environment for 4-6 year olds’).

- Yet instead of simply sitting back and allowing our ‘skills at off-line reason’ to take charge and solve the problem, we go to **extraordinary lengths to create a variety of real-world mock-ups.**

1. The mock-ups etc are **not incremental bits of the final structure**. The materials serve no ultimate productive purpose save that of enabling better thinking (see Kirsh and Maglio on 'epistemic actions')

2. Mock-ups vary greatly in their structure and contents , but what they all have in common is that they '**enable the designer to get at the future situation of use'.**

3. Different techniques re-create (pre-create) **different aspects** of this future situation of use.

4. Given the nature of the task, **the designer CANNOT use the world as its own best model (a non-existent building cannot be its own model).**

But she can *use a model as her own best world*, i.e. create a kind of surrogate situation in which to deploy many of the same kinds of strategies and shortcuts encountered in non-disengaged cases.

Surrogate Situations are not, typically, miniature versions of the real thing, and do not typically support all the interactions we might have with the real thing (flight simulators may be an exception).

Instead, the surrogates are useful precisely because they allow us to become coupled, in a perceptuo-motor fashion, with select (and often quite abstract) elements of the target situation.

Examples

- Page lay-out folk are explicitly counseled (Black 1990) to keep their thumbnails rough (and their roughs exploratory!), to leave out detail, and to focus only on the *relations* between major elements.

- Industrial prototypes will be multiply generated, some for general form (eg the Ray-Gun shaped power tool mock-up), others for color and texture, others for actual (but partial) function etc

- Similarly, consider the range of nautical props and scaffoldings displayed by Hutchins who notes that each artifact allows the user to tackle some select aspects of the problem.

- Or artists sketches that likewise target very select aspects of a project (eg the detailed story in Van Leeuwen et al 2000, and Clark (2001)) making these available for focused perceptual re-encountering and refinement.

- Nearly all Surrogate Situations share this signature:

simplify-focus-divide-and-conquer

TMTMFW-TMWT

J.S. Deloache (1991) Symbolic functioning in very young children: Understanding of pictures and models.
Child Development 62 736-752

(also DeLoache (1995)

Shows young children (2-3 years) a model of a room.

The child watches as a model toy is hidden under a model piece of furniture, and is told that the real toy is 'hidden in the same place in the real room'.

Children are better able to find the real toy when the model is a 2D picture rather than a 3D scale model.

DeLoache suggests this is because as the mock-ups physical properties become more salient and afford a wider range of interactions, the child's ability to use it as a symbol decreases.

Reducing interactive salience by eg placing the 3D model behind glass improves performance considerably.

Bassok and Holyoak (1989) and Bassok and Olseth (1995) find similar results with cross-domain transfer in adults.

Markman and Gentner (1993) show that grasp of abstract relations in a scene improves when the richness of the representation of objects is decreased.

Goldstone (in press) shows several other cases where " in contrast to a situated learning perspective, decreasing the strength of the real-world link was beneficial" (p.50)

An underappreciated virtue of many surrogate situations is the way they alter and relax the heavy-duty temporal constraints on normal performance.

Sure, there are still dense looping perceptuo-motor interactions.

But there are **no temporal constraints that act like the ones involved in eg returning a tennis serve.** When I interact with a mock-up, I can take my time, and I can visit and re-visit the mock-up as required.

In fact, in one important range of cases, where we are actively generating the elements of the mock-up as we go along, the **rate of production of elements to respond to is itself under our own control**

(think, e.g. of planning a party using pen and paper, or slowly creating those thumbnail sketches).

SUSPICION

Maybe it is this temporal relaxation that allows us to deploy a phylogenetically more recent set of neural cognitive strategies: 'ventral stream' strategies focused on object identification and classification.

These make contact with episodic memory systems and explicit stored knowledge, and are major players in time-delayed and imagination-based responses. (see Milner and Goodale 1995 for a (too) strong version of this, and Clark (1999) for one attempt at a more balanced account).

More generally, the use of surrogate situations may play a special role in allowing neural circuits that(for whatever reason) vary their activity at relatively slow time-rates to participate in new kinds of problem-solving.

What is the nature of the internal representations (or ,if you prefer, resources) that we bring to bear on stable external symbols, diagrams and mock-ups and that allow us to **use these items as representations,** to use them **as** stand-ins?

This is a large unanswered question.

To the extent that these resources are **simply the same** as those deployed in time-intensive perceptuo-motor contexts, then an internal continuity claim is well-founded (though the overall system may still have novel properties).

My guess, though, is that there is both **internal and overall-systemic (extended system) discontinuity**, with phylogenetically more recent resources playing some special and ill-understood role in our symbolic/model-using practice.

(see Deacon on symbol use, Dennett on ‘florid representing’)

External (and internal) stand-ins are not a privileged locus of control or content. They are just useful anchor points around which complex, often slower time-scale, neural dynamical processes can swirl and coalesce.

But by relaxing strict temporal constraints and encouraging the progressive removal of concrete detail, these anchor points allow new kinds of thinking to emerge, and new kinds of neural circuit to begin to participate in our problem-solving activity.

(see Clark, in pregress (progress seems too strong a word))

4. The Morals: Cognition beyond the Flesh

First Moral:

If you thought the mole cricket's singing burrows were 'organs of extreme perfection', reflect a little on ours.

Our best cognitive technologies are singing burrows of the mind.

And we do not just use these burrows to think.

We **use the burrows to help build better burrows.** We build better tools to think with, and use these tools to discover still better tools to think with

And **we tune the way we use them,** by using some burrows to educate ourselves to use our best burrows better.

And we **tune the way we tune the way we use them**, by using some burrows to help build better burrows for educating ourselves in the use of our burrows.

(these are all different, honest!)

A cascade of ‘extended cognitive physiologies’ achieved by progressively fitting an open-ended sequence of technologies to somewhat plastic human brains.

Just as in the case of the mole cricket, the genetic program for all this can be surprisingly minimal.

But once it is up and running, we are barely, if at all, constrained by the limits of the on-board apparatus that fitted us to the good old Savannah.

(See Clark, *Natural-Born Cyborgs?* (forthcoming))

Second Moral:

We interact with these developing webs of cognitive support in ways that are indeed ‘embodied’’ and ‘embedded’.

But we should not suppose, at least in the case of surrogate situations, that the interaction dynamics are simply the same as those that describe more basic cases. This is because:

1.The power of surrogacy does not lie in the recreation of all the concrete detail of the original.

Quite the reverse.
In place of rich concrete detail and time-pressure on physical response, we find aspect-sharpening de-concretization.

2. Surrogate situations afford a more relaxed (often self-controlled) temporal profile.

There is surely a good chance that these two differences also invite the use of differently specialized neural circuitry.

Final Moral:

Scaling up new embodied approaches to confront the full gamut of human cognition requires a modestly brave step.

It requires us to take our technological and cultural props and scaffolds seriously, and to treat these larger systems as extended, and perhaps radically innovative, cognitive architectures.

That means developing a science of the mind, that although embodied and embedded, reaches far beyond the flesh.

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